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ABSTRACT

Reported is a study of the efficacy of mutually aided learning in science, defined as the systematic and long term use of high school students in an instructional role in elementary school science classes. A group of five or six high school juniors or seniors served as instructors in an elementary school science class, with each high school student, called a learning assistant, working closely with about five elementary students. The learning assistants taught forty minutes per session and three sessions per week for 13 weeks. The basic design of the study included comparison of classes which had teams of learning assistants with classes involving only the regular teacher. Eight intermediate level classes using science units developed by the Elementary Science Study were involved. The results of the study indicated that (1) the three major factors of school, teacher, and learning assistant influence student outcomes, and (2) there is an interaction between the factors of school and learning assistant. This work was prepared under an ESEA Title III contract. (LC)

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A Study of Mutually Aided Learning

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The research reported herein is a study of the efficacy of mutually aided learning in science. As used in this instance, mutually aided learning refers to the systematic and long term use of high school students in an institutional role in elementary school classes.[1] A group of five or six high school juniors or seniors serve as instructors in an elementary school class during the time devoted to science, with each high school student (titled as learning assistant) working closely with about five elementary students. The elementary school teacher is still present and in charge of her class, but the instructional role is given almost entirely to the learning assistants.

The learning assistants are volunteers from among the more science-prone high school students who are willing to devote an hour of the school day to this activity for a semester or year. For the first three weeks of the semester, this time is devoted to a study of the specific elementary science units that will be used during the semester and the educational philosophy underlying the desired use of the units. During the remainder of the semester, they are in charge of the science instruction in an elementary school class. The learning assistants teach fo rty minutes per session and three sessions per week for 13 weeks which provides the allotted amount of time for science during the semester in

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[1]This pattern was described as "learning by teaching" in Zacharias, Jerrold R., "Learning by Teaching" in Educational Services, Inc., Work in Progress, 1966.

the elementary school class. During the other two days per week, the learning assistants use this period for planning and preparation.

This activity is the focus of an E.S.E.A. Title III Project in the Cherry Creek School District, Englewood, Colorado. This district is a largely residential community in the southeastern suburbs of metropolitan Denver. Approximately 7300 students are served by nine elementary schools, two junior high schools and one senior high school. The school community has traditionally striven to develop a quality educational program and has supported a per-pupil expenditure level that ranks among the highest in Colorado.

The project began with science and has expanded to include art and mathematics in its second year of operation. The research reported herein is but a part of an extensive formative and summative evaluation in which information was sought for use in making decisions concerning the operation and evolution of the project during the first year. This portion of the evaluation was designed to determine the project's impact upon the science achievement, ability to apply science concepts, divergent thinking ability, and convergent thinking ability of the participating elementary school children.

Design of the study

The basic design of the study included comparison of classes which had teams of learning assistants with classes involving only the regular teacher. Classes were compared on the

basis of several postest measures of student outcomes as dependent variables. Eight classes (four at each of two schools) were included in the study which was conducted during the first half of the 1968-69 school year. Four of the classes (two at each school) had learning assistants and in each of the other four classes science was taught by the regular teacher. All of these intermediate level classes were using science units developed by the Elementary Science Study (ESS). In School A, which was nongraded, the assignment of students to the experimental and control classes was done randomly. In School B, which had a conventional organizational pattern, assignment of students to classes was done by the usual school procedures, which, although not random, was intended to produce equivalent groups. Examination of I. Q. scores for the students in these classes showed that the means and standard deviations of these scores were at least as uniform as in the case of the randomly assigned classes in the other school. The statistical procedure chosen for the analysis included blocking on I. Q. which provides further assurance that outcome differences found between classes in this school were not due to differences in I. Q. for the samples. Comparisons of the classes in both schools were made on the basis of post tests administered at the end of the semester in which the study was conducted.

Measuring Instruments

A very extensive set of measures of student outcomes, or dependent variables, was employed to determine the relative effects

of using learning assistants in the elementary school science classes. These measures included (1) a concepts application test, (2) a standardized science achievement test, (3) a creative thinking test composed of three scales and (4) a critical thinking test composed of three scales.

The concepts application test (CAT), developed specifically for use in this study, was based on the science units used by the classes. The test is not a conventional paper-and-pencil instrument requiring only a verbal comprehension of the concepts. Rather, it requires that children be able to apply their knowledge in concrete situations. Forty stations were established in a room, each having a set of materials and accompanying questions requiring observation and/or manipulation of the materials prior to answering the question. Each station was manned by a learning assistant who maintained the materials and recorded responses. The group of children taking the test rotated through the stations on a fixed but liberal time schedule which permitted them to respond to each questions. The KR_{20} reliability of the test was .686.

The second instrument was the science portion of the Stanford Achievement Test which is designed to measure elementary school students' understanding of general science knowledge. The KR_{20} reliability[1] of the test when used with the children in the

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[1]Ebel, Robert L., Measuring Educational Achievement (Englewood Cliffs: Prentice-Hall), 1965, p. 318.

study was .828.

The third instrument, the creative thinking portion of the "Boulder Tests of Critical and Creative Thinking,"[1] is designed to measure 4th, 5th, and 6th grade students' ability to think divergently (sometimes referred to as creative thinking ability) in a science context. It provides children with the opportunity of responding to open ended questions in which a large number of responses is encouraged and scores are obtained on three scales: (1) fluency - the number of responses, (2) flexibility - the number of different types of responses, and (3) originality - a measure of the uniqueness of responses. The Cronbach Alpha reliability coeffients[2] for the three scales are .710, .505, and .682 respectively.

The fourth test, the critical thinking portion of the "Boulder Tests of Critical and Creative Thinking,"[3] is a measure of children's ability to think critically in a science context. It has three scales designated as measures of the ability to recognize assumptions, to make inferences, and to reason. The Cronbach Alpha reliabilities[4] of these scales are .721, .550, and

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[1]Struthers, Joseph A., Boulder Elementary Science Project, final report of PACE Project 1312, Boulder Valley School District Re 2, Boulder, Colorado 1969. (mimeo)

[2]Cronbach, J. L., "Coefficient Alpha and the Internal Structure of Tests," Psychometrica, 1951, 16.

[3]Struthers, op. cit.

[4]Cronbach, op. cit.

.790 respectively.

Statistical Analysis

The statistical analysis was conducted independently for each of the two schools in the study within a 4x2x2 nested factorial designs in which the independent variables were teacher (4 levels), learning assistant (2 levels - learning assistant or no learning assistant), and I. Q. (2 levels). Teacher was nested in learning assistant.

Results and Interpretation

The results of the above analyses, including means and the F ratios from the analysis of variance, are given in tables 1-4. The main results of these analyses are summarized in table 5. The remainder of this report is an explanation of the results which are summarized in table 5 and an interpretation of them.

Tabe 5 summarizes the results of the analysis of variance for the factorial designs for each of the two schools including teacher, learning assistant, and I. Q. as factors. All main effects and interactions which were found to be significant are indicated by the level of significance in the table. A blank indicates that the effect for the indicated dependent variable was not large enough to be significant at the .05 level.

Table I

Means of dependent variables for School A

	Learning Assistants		No Learning Assistants	
	Teacher 1	Teacher 2	Teacher 3	Teacher 4
CAT				
high I.Q.	.50857	.46000	.47286	.45000
low I.Q.	.35143	.38571	.35857	.37429
Achievement				
high I.Q.	.63889	.64667	.6411	.65000
low I.Q.	.47667	.43556	.49556	.54000
Fluency				
high I.Q.	8.77778	8.74222	11.81556	10.22222
low I.Q.	6.66778	8.40667	10.11000	8.18444
Flexibility				
high I.Q.	4.40880	4.70333	5.74222	5.77667
low I.Q.	3.96222	3.99889	5.44444	4.18556
Originality				
high I.Q.	11.25889	10.85222	16.11111	16.26000
low I.Q.	7.07556	10.44556	15.14778	9.77667
Assumptions				
high I.Q.	.84778	.78778	.90889	.85000
low I.Q.	.79333	.81667	.87667	.80111
Inference				
high I.Q.	.64111	.70111	.66111	.68222
low I.Q.	.45333	.52556	.62778	.55556
Reasoning				
high I.Q.	.66333	.73667	.74222	.83222
low I.Q.	.59333	.51000	.65778	.60222

Table 2

Analysis of Variance tables for School A

CAT

	SS	df	F
L	.0022	1	.181[c]
I	.1554	1	12.79[bc]
T(L)	.0004	2	.016
LI	.0015	1	.123[c]
TI(L)	.0146	2	.57
P(LTI)	.6167	49	

Achievement

	SS	df	F
L	.0187	1	1.11[c]
I	.4449	1	26.4[bc]
T(L)	.0089	2	.26
LI	.0156	1	.93[c]
TI(L)	.0082	2	.23
P(LTI)	1.1284	64	

Fluency

	SS	df	F
L	67.3574	1	6.11[ac]
I	43.0901	1	3.91[c]
T(L)	34.3888	2	1.72
LI	1.8948	1	.19[c]
TI(L)	7.3328	2	.36
P(LTI)	645.7751	64	

Flexibility

	SS	df	F
L	18.6864	1	9.28[bc]
I	10.3968	1	5.17[ac]
T(L)	3.6200	2	.90
LI	.6124	1	.30[c]
TI(L)	3.9131	2	.97
P(LTI)	129.3629	64	

Originality

	SS	df	F
L	350.9925	1	2.83[c]
I	162.9915	1	18.34[bc]
T(L)	81.1191	2	1.35
LI	9.1806	1	2.77[c]
TI(L)	100.6506	2	.60
P(LTI)	2142.6533	64	

Assumptions

	SS	df	F
L	.0411	1	3.66[c]
I	.0128	1	1.14[c]
T(L)	.0437	2	1.98
LI	.0035	1	.31[c]
TI(L)	.0162	2	.74
P(LTI)	.7031	64	

Inference

	SS	df	F
L	.0475	1	2.83[c]
I	.3081	1	18.34[bc]
T(L)	.0452	2	1.35
LI	.0465	1	2.77[c]
IT(L)	.0199	2	.60
P(LTI)	1.0750	64	

Reasoning

	SS	df	F
L	.1233	1	4.083
I	.4201	1	13.73[bc]
T(L)	.0029	2	.045
LI	.0004	1	.013[c]
TI(L)	.1029	2	1.66
P(LTI)	1.9774	64	

L = learning assistant
I = I.Q.
T = teacher
P = pupil

a. significant @ .05
b. significant @ .01
c. Based on pooled error term

Table 3

Means of dependent variables for School B

	Learning Assistants		No Learning Assistants	
	Teacher 1	Teacher 2	Teacher 3	Teacher 4
CAT				
high I.Q.	.53300	.47700	.39600	.49100
low I.Q.	.49100	.47200	.32300	.38100
Achievement				
high I.Q.	.63800	.61200	.63100	.64700
low I.Q.	.52500	.52200	.50500	.59800
Fluency				
high I.Q.	13.18444	12.70222	8.59222	12.74111
low I.Q.	12.74222	6.74000	9.33222	10.92667
Flexibility				
high I.Q.	5.96222	5.26000	4.74000	6.03778
low I.Q.	5.14667	4.25889	4.70444	5.11222
Originality				
high I.Q.	19.33222	17.22333	11.37111	18.22111
low I.Q.	16.99889	9.48222	9.70333	14.92556
Assumptions				
high I.Q.	.91222	.87222	.87000	.87222
low I.Q.	.72333	.88667	.75444	.84000
Inference				
high I.Q.	.60667	.64889	.66444	.62222
low I.Q.	.62333	.55444	.52889	.54000
Reasoning				
high I.Q.	.81889	.85778	.79778	.70667
low I.Q.	.73889	.67556	.55778	.54667

Table 4

Analysis of Variance tables for School B

CAT

	SS	df	F
L.	.1824	1	13.52[bc]
I	.0661	1	4.89[ac]
T(L)	.0726	2	2.75
LI	.0231	1	1.71
TI(L)	.0068	2	.26
P(LTI)	.9482	72	

Achievement

	SS	df	F
L	.0088	1	.58[c]
I	.1786	1	11.74[bc]
T(L)	.0318	2	1.03
LI	.0010	1	.07[c]
TI(L)	.0161	2	.53
P(LTI)	1.1100	72	

Fluency

	SS	df	F
L	16.0461	1	.19
I	62.9255	1	1.51
T(L)	168.8263	2	4.81[a]
LI	31.9600	1	.77
TI(L)	83.2401	2	2.37
P(LTI)	1122.4283	64	

Flexibility

	SS	df	F
L	.0013	1	.0002
I	8.6806	1	9.34
T(L)	12.2333	2	4.32[a]
LI	.8235	1	.69
TI(L)	1.8597	2	.66
P(LTI)	90.7572	64	

Originality

	SS	df	F
L	87.4283	1	.33
I	254.4016	1	7.08
T(L)	536.3772	2	4.79[a]
LI	29.3889	1	.76
TI(L)	71.7609	2	.64
P(LTI)	3574.5440	64	

Assumptions

	SS	df	F
L	.0038	1	.15
I	.1168	1	2.15
T(L)	.0516	2	2.13
LI	.0008	1	.015
TI(L)	.1086	2	4.49
P(LTI)	.7759	64	

Inference

	SS	df	F
L	.0068	1	.60[c]
I	.0983	1	8.71[bc]
T(L)	.0038	2	.17
LI	.0221	1	1.96[c]
TI(L)	.0342	2	1.50
P(LTI)	.7288	64	

Reasoning

	SS	df	F
L	.2616	1	14.9[ac]
I	.4934	1	28.1[ac]
T(L)	.0249	2	.70
LI	.0214	1	1.22[c]
TI(L)	.0379	2	1.07
P(LTI)	1.1297	64	

L = learning assistant
I = I.Q.
T = teacher
P = pupil

a. significant @ .05
b. significant @ .01
c. Based on pooled error term

Table 5

	CAT	ACHI	FLUE	FLEX	ORIG	ASSU	INFE	REAS
School A[a]								
Learning Assistants			.05	.05	.05			.05
I. Q.	.01	.01		.01	.01		.01	.01
Teacher								
Learning assistant x I. Q.								
Teacher x I. Q.								
School B[b]								
Learning Assistants	.01							.01
I. Q.	.05	.01					.01	.01
Teacher			.05	.05	.05			
Learning Assistants x I. Q.								
Teacher x I.Q.					.05			

[a]All significant differences on the learning assistant factor are in favor of the classes with no learning assistants. All I.Q. differences are in favor of the high I. Q. level.

[b]The significant differences on the learning assistant factor are in favor of the classes with learning assistants. I. Q. differences are in favor of the high I. Q. level. The teacher effect has the same pattern for all creativity measures. The teacher x I. Q. interaction effect indicates a differential teacher effect for the low I. Q. students.

There are at least three major rival hypothesis that must be considered in attempting to account for differences in post test scores that occurred in the eight classes involved in the evaluation. These three hypotheses are statements of the possible effects of three variables: (1) the absence or presence of learning assistants, (2) the influence of the classroom teacher, and (3) the overall influence of the school in which the class is located. As indicated previously, all three factors were incorporated into the factorial design for the study. The analysis of the data indicates that all three factors are influential and there are probably some interactions among those factors.

As shown in Table 5, the School A classes without learning assistants performed significantly better on four of the eight scales. Interpretation of these results could be influenced by the fact that the two control class teachers in School A were experienced in the use of the ESS science units while the use of these units was new to the teachers who had learning assistants. (In both schools, however, both the experimental and control teachers had voluntered to have learning assistants in their classes.) In School B, however, the classes with learning assistants performed significantly better on two of the eight scales.

These results lead to the conclusion that there is an interaction between the factors of school and learning assistant. An analysis of the combined data from the two schools should show the extend of this interaction. An analysis within an 8x2x2x2

nested factorial design in which the independent variables are teacher (8 levels), school (2 levels), learning assistant (2 levels), and I. Q. (2 levels) is in process at this writing. A question of great interest for which no conclusions can be drawn, is the nature of the differences between the schools which leads to these differing outcomes.

The teacher factor was not significant on any of the dependent variables in School A, but it was on all three creativity scales in School B. This latter result is not surprising since previous research has shown that the teacher can have a pronounced effect upon measures of students' creativity.

The above findings make if difficult to draw conclusions which would have wide generalizability. It is apparent that there are many factors which cause variations in student outcomes. In this study there were three major factors, school, teacher, and learning assistant, which were found to have an influence. This is consistent with other research findings and in turn provided evidence in support of the position that the primary determiners of outcomes lie somewhere in the complex pattern of interactions between students and the many individuals who constitute "their world." It seems safe to say, however, that whatever these major determiners are, their influence, either positive or negative, is not mainly established by the absence or presence of learning assistants in the classroom.

In terms of student outcomes, this evaluation provides little evidence that supports either the continuation or elimina-

tion of the use of learning assistants in elementary school classrooms. This result is not surprising, and in fact, is probably what would be expected, in view of what previous research has shown about the complex nature of teaching and learning. The findings of this evaluation, do, however, support the continuation of this project, as an experimental and innovative venture in view of other potential benefits to education. It may well be that the major value of mutually aided learning is the effect upon other persons such as learning assistants for elementary school teachers or upon some aspect of the school system or curriculum. Informal subjective appraisals, for example, indicate, that participation in this activity has had a noticeable impact upon the high school students, particularly their view of teaching as a career.

Evaluation of the mutally aided learning project is continuing with the main focus during the 1969-70 school year being upon its impact on the learning assistants and the teaching style of the elementary school teachers. Since the learning assistants constitute a portion of the population served by the school, the effect of those activities upon high school students is of major importance. Because of the known influence of factors such as teacher morale and "school climate" upon student outcomes it is also important to study the influence of the project upon elementary teachers, and the social institution of which they and their students are a part